From the Editor's Desk

There are many causes of concrete deterioration, out of which alkali-aggregate reaction is one of the predominant factors in dams, pavements and infrastructure projects. Alkali-aggregate reaction is a term mainly referring to a reaction which occurs over time in concrete between the highly alkaline cement paste and the non-crystalline silicon dioxide, which is found in many common aggregates. This reaction can cause expansion of the altered aggregate, leading to spalling and loss of strength of the concrete. Considering the more thrust given to infrastructure projects where durability of concrete needs to be assessed, we have brought forth some of the issues such as petrographic and rapid chemical method for diagnosing the alkali-aggregate reaction and their control.

The problem of Alkali-silica reaction was believed to be non-existent in India till 1983, when its occurrence was diagnosed in two concrete dams. Spillway of Hirakud (Odisha) dam and spillway piers and radial gate pedestals of Rihand Dam (U.P.) were the first two confirmed cases of cracking due to alkali-silica reaction in India. Up to this time, it was believed that Indian aggregates were not expansively reactive. However, India has numerous sources of potentially reactive aggregates with a range of alkali contents and water-cement ratios normally adopted in India, the molar concentration of alkali can be sufficiently high to give rise to unsafe reactions with reactive aggregates.

In India, there are cases where concrete has become unserviceable just after one year because of alkali-aggregate reaction. The basalt rocks of Deccan Plateau, Hyderabad, Madhya Pradesh, Kathiawar, Punchal hill of Jammu & Kashmir, Bengal and Bihar should be thoroughly tested before use in concrete. Limestone containing chert nodules is also highly reactive. Bijawar lime stone is known to be high in chert for which it is highly reactive. Madhya Pradesh, Rajasthan, Punjab and Assam region containing chert in lime stone is reactive. Similarly, sandstone containing silica minerals like chalcedony, crypto to microcrystalline quart or opal are highly reactive.

The high expansion of mortars composed of some seemingly innocuous aggregates such as granites, charnockites and even quartzites are considered to be reactive. It is suggested that alkali-aggregate reactivity should be viewed from new angles, i.e., the textural features observed in silica minerals should be carefully studied.

Alkali-silica reaction (ASR) in concrete is a reaction between certain silicious constituents in the aggregate and the alkali-sodium and potassium hydroxide which are released during the hydration of Portland cement. A gelatinous product is formed which imbibes pore fluid and in so doing expands, inducing an internal stress within the concrete. The problem of alkali-silica reaction can be overcome by:

- The use of non-reactive aggregates
- The use of low-alkali cement, namely cement with an equivalent sodium oxide (Na_2O) content of 0.6% by mass or less. No allowance is made for possible alkali contributions from sources other than the Portland cement.
- Limiting the cement content to 500 kg/m^3
- The use of pozzolana, slag and other substitutes for part replacement of cement
- The use of ASR – inhibiting salts
- Using controls on service conditions, namely preventing contact between concrete and any external source of moisture.

Petrographic examination of aggregates to evaluate their reactivity with alkalies is an optical inspection to establish the presence and quantity of potentially reactive forms of silica within the aggregate particles. In this test, it is sometimes difficult to establish which specific particles and minerals are responsible for gel formation. The Indian Standard Code also gives a second method of determining the potential reactivity of aggregates by rapid chemical method. This test can be performed in just three days, but for many aggregates the results are not conclusive.

For long term durability of concrete, the proposed aggregates to be used in the construction should be tested for reactivity with the combination of the same cement which is to be used in the construction. Conventional method of test for alkali-silica reaction is very time consuming, as it requires a time of six months or more. A construction site cannot wait for so long period. Keeping this in view, trials should be done for the accelerated chemical method of test and the petrograhic test.

This issue of ReBuild discusses the mechanism of alkali-silica reaction, alkali-carbonate reaction, factors affecting these two types of reactions, materials to be used to control these reactions and some case studies related to alkali-aggregate reactions from India along with their control measures. Though this is not a common feature to be experienced by any engineer or architect but more attention needs to be given by concrete technologists for durability of the structures during their design stage. This issue of ReBuild is a concluding part of ongoing series on non-destructive testing and we hope the case studies will be beneficial to our readers.